Reliability Aspects for Electrical Distribution System Management

Rabah MEDJOUDJ
Laboratory of Modeling and
Optimisation of Systems - LAMOS-
University of Bejaia
Algeria
medjoudj@yahoo.fr

Djamil AISSANI
Laboratory, LAMOS
University of Bejaia
(Algeria)

Abstract

The evaluation of system reliability can be considered as a tool to manage an electrical distribution system during its operating mode. The management through reliability aspects is done through out many phases, such as: data collection and its processing, reliability measures and requirements, reliability empROVement, cost-benefit analysis and preparation of recommandations. An application is done for a practical case and results are obtained.

Introduction

The components are independent and can be considered in series. Much of validity of the results of the system reliability studies depend on how good the failure data information is good. Most utilities maintain a data bank in which all the relevant information derived from field experience in the last ten years or so. Forecasts are obtained by BOX and JENKINS modeling . To improve reliability indices, technical and organizational measures are considered taking into account cost-benefit analysis and some decision criteria with effects of incertainties of data.

1 Statistical Processing

More than 60% of interruptions appear in the distribution level, for this , a particular interest is granted to this part of networks "Laturnus (1993). The informations of failures are inputs to the system reliability studies which are introduced for forecasts establishment by BOX and JENKINS models.

1.1 BOX and JENKINS Models

The analysis of the data rests mainly on the taking into account of the operations below "Medjoudj (1994):

- Observation of values in the past on generally fixed and equidistant dates.
- Suggestion of working assumptions allowing to justify the use of certain methods of forecasts.

For data treatment, the generating stochastic process is supposed to be discrete, stationary and it admits a distribution fixed a priori. The construction of the model obeys to three successive operations: Presentation, identification and validation of the model. The identification operation consists of determining the order and the parameters (p, q) of the model. It is based on the theorical behavior of the correlograms and partial correlograms. It resides in the comparison between this behavior and that of the estimators of the coefficients of the autocorrelations and the partial autocorrelations. The validation of the model consists of knowing if the model chosen in the phase of identification and whose parameters were estimated, can be regarded as valid. Thanks to the test of Student, one can test the rejection of the parameters of the model.

1.2 Data Collection and processing improvement

Nowadays to be relevant, the decisions must be founded on a solid basis of expertise on the data bases of the system, the failures and the damages. Tools allowing to help to carry out this sounding are: the recorders of defects and reactions of protections in the source stations and the detectors of defects with memory, dated and placed at various places of the system. Those materials are accompanied by software assistance for the examination and by statistical tools for processing the recordings. It can apprehend the risk of defects of components, their residual life time according to their type, their age and their environment. Expert systems are developed to analyse and recognize the signatures of the various defects and to contribute to the choice between the maintenance operation and the renewal of a component `Medjoudj (1994).

2 Reliability Indices

Reliability is always defined as the probability of a device or system performing its function adequately , for the period of time intended, under the operating conditions intended. In addition to this, especially for an electrical system, we can consider a level of reliability as an objective to attempt by the company which is formulated by a number of indices which are possible to quantify such as:
From the availability point of view, reliability indices are: the annual average frequency of failures, the average duration of failures, the annuel average duration of failures and the non-delivered energy to the consumer "Endrenyi (1978):
From the delivered product quality point of view, the level of reliability is evaluated through: the deviations of the voltage level, the deviations of the voltage curve (harmonic distortions)and the deviations of the frequency.
To improve the reliability level, technical and organizational measures are considered during the planning and the exploitation of electrical distribution network. The actions currently carried out at the time and considered as alternatives are `medjoudj and Aissani (2002):

a) reorganization of the networks for more flexibility in failure conditions.

b) automation of networks by installing the interlocking in lines and the fault detectors.

c) realization of work under tension.

d) automation of failure research .

3 Failure research method

Actually, this operation is done manually by actions of protections along the affected departure. In this work, we introduce the automatic research of faults, which consists on choosing a step N according to the number of sub-stations implanted along of the departure or according to the length of this departure. The strategies of refeeding after the detection of failure is an important parameter to consider in the reliability level evaluation `Medjoudj (1994).

4 Cost-Benefit Analysis

The factors to consider are the incremental costs of reliability, the benefits expected from a change in reliability and the allocation of the reliability investment among the various parts of the system and new material.
The final objective is to minimize the expectation of the total cost function `Medjoudj and Aissani (2002).

$$Minimize \quad I_t + R_t + F_t \tag{1}$$

Where:
I_t: cost of investments,

R_t: cost of operation expenses (losses),
F_t: cost of economic inconvenience,

5 Application to the 30KV system of Bejaia, Algeria

The results processing of reliability indices and the results of BOX and JENKINS models are carried out respectively on ZV developed in Pascal 6.0)̀Jungnckel and Haim (1992) and Stat Graph software.

5.1 BOX and JENKINS Models

Failure models for different components are:

- Electric lines:
  $Y_t = 0.3485Y_{t-1} + 0.7735Y_{t-2} + 0.8354\epsilon_{t-1} + \epsilon_t$.
- Electric underground cable:
  $Y_t = 0.291Y_{t-1} + 0.8353Y_{t-2} + 0.8506\epsilon_{t-1} + \epsilon_t$.
- Electric junction nodes:
  $Y_t = 1.0106Y_{t-1} + 0.1373Y_{t-2} + 0.3325\epsilon_{t-1} + \epsilon_t$.
- Total incident of departure VILLE II:
  $Y_t = 0.2884Y_{t-1} + 0.2117Y_{t-2} + 0.3009Y_{t-3} + \epsilon_t$.

5.2 Reliability Level and Cost

The reliability indices are calculated for alternatives defined as below:

i) Alternative 1: Current state of the network

ii) Alternative 2: Automation of the network by:

  a) Installation of faults indicators .

  b) Installation of faults indicators an reclosers in line.

iii) Alternative 3: Reorganization of the network, by changing cables. This correspondes to the failure rate of cable in accordance with the international data.

The results are already presented in ̀medjoudj and Aissani (2002).

6 Decision criteria

To illustrate these criteria, one consider the variation of annual demand curve through out a given study duration, from where the variation factor r is deduced. For a r_j value of r is associated the probability Qj. In this work we consider Max-Min and Bayes-Laplace criteria.

6.1 Max-Min criteria

For a given alternative v_i , representing an exploitation mode of the system and for any value r_j, one obtain a new value of the total cost of v_i given by K_j. With: $i = 1, 2, ...$ and $j = 1, 2, ...$
One process the matrix D_{MM} of v_{ij} as follows:

$$D_{MM}[v_{ij}] = \begin{array}{|cc|cccc|} \hline & (K_j) & K_1 & K_2 & \dots & K_j \\ (V_i) & (r_j) & r_1 & r_2 & \dots & r_j \\ \hline V_1 & & v_{11} & v_{12} & \dots & v_{1j} \\ V_2 & & v_{21} & v_{22} & \dots & v_{2j} \\ \vdots & & \vdots & \vdots & & \vdots \\ V_i & & v_{i1} & v_{i2} & \dots & v_{ij} \\ \hline \end{array}$$

According to the index j , one search the minimal value of the total cost and obtain i values from where one retain the maximal one. The required value is expressed by Muschik (1989):

$$Z_{MM} = \max_i \quad \min_j [v_{ij}] \tag{2}$$

Which indicates that the i^{th} alternative is retained.

6.2 Bays-Laplace criteria

For each value r_j of the variation factor of the annual demand r is associated one probability Q_j , with $\sum Q_j = 1$. One process the matrix D_{BL} of v_{ij} as follows:

$$D_{BL}[v_{ij}] = \begin{array}{|cc|cccc|} \hline & (K_j) & K_1 & K_2 & \dots & K_j \\ & (r_j) & r_1 & r_2 & \dots & r_j \\ (V_i) & (Q_j) & Q_1 & Q_2 & \dots & Q_j \\ \hline V_1 & & v_{11} & v_{12} & \dots & v_{1j} \\ V_2 & & v_{21} & v_{22} & \dots & v_{2j} \\ \vdots & & \vdots & \vdots & & \vdots \\ V_i & & v_{i1} & v_{i2} & \dots & v_{ij} \\ \hline \end{array}$$

According to the index j, one do the sum of $v_{ij}Q_j$, and obtain i values. From these, one retain the maximal one. It is expressed by:

$$Z_{BL} = \max_i \sum_j [v_{ij}Q_j] \tag{3}$$

which indicates that the i^{th} alternative is retained.

Conclusion

For the electrical distribution system , We can formulate the management as a set of decisions which arrounds towards various technical and organizational measures. All these considerations are based on the reliability aspects which needs a perfect knowledge of data, their processing and their interpretations. Finally, the goal is to achieve to the objective usually aimed by the company of electricity which consist to attempt an optimal balance between high quality of service, efficiency, safety and their total cost.

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